Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 38 (2012) 2473 – 2483

Procedia Engineering

www.elsevier.com/locate/procedia

ICMOC 2012

Mobility based energy efficient multicast protocol for MANET

N.Fareena[a]*, A.Shunmuga Priya Mala[b], Dr.k.Ramar[c]a*

[a]*Assistant Professor,Computer science and Engineering,Anna University of Technoloy,Tirunelveli,India*
[b]*PG Scholar,Computer science and Engineering,Anna University of Technoloy,Tirunelveli,India*
[c]*Principal,Einstein college of Engineering, Tirunelveli,India*

Abstract

This paper presents a new multicast routing protocol named as Mobility based Energy Efficient Multicast Protocol (M-EEMC). The aim of this protocol is minimizing the energy dissipation of the Mobile Ad-hoc network. This M-EEMC protocol is a combination of tree and mesh based routing scheme. This protocol is used to establish and maintain an active multicast tree surrounded by a passive mesh within a mobile ad hoc network. The multicast mesh is created by using route discovery concept. Pruning mechanism is used to eliminate the redundancies of mesh that is created by route discovery approach and it creates the multicast tree. M-EEMC effectively uses the knowledge of neighborhood node density and mobility so that they complement each other in discovering stable routes in a more energy-efficient fashion. Energy efficiency is achieved by eliminating most of the redundant data receptions. The proposed scheme is simulated over a large number of MANET nodes with wide range of mobility and the performance is evaluated. It is observed that proposed scheme produces better packet delivery ratio, less energy dissipation and reduced packet delay compared to on-demand multicast routing protocol (ODMRP).

Keywords :MANET; Routing; Multicasting; Relay node;Multicast Group Member node; Multicast mesh; Multicast tree; Energy Efficiency; Packet Delivery Ratio;

* Corresponding author. Tel.: +0-000-000-0000 ; fax: +0-000-000-0000 .
E-mail address: author@institute.xxx .

1877-7058 © 2012 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
doi:10.1016/j.proeng.2012.06.292

1. Introduction

A mobile ad-hoc network (MANET) [1] is a self-configuring infrastructure less network of mobile devices connected by wireless links. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Routing is one of the key issues in MANETs due to their highly dynamic and distributed nature.

In particular, energy efficient routing may be the most important design criteria for MANETs since mobile nodes will be powered by batteries with limited capacity. In a wireless ad hoc network environment some nodes may want to communicate with other nodes outside their maximum transmission range, thus requiring other nodes to forward packets on behalf of source nodes. Multicasting is a communication process in which the transmission of packets (message) is initiated by a single user and the message is received by one or more end users of the network [2].

The set of nodes that support a multicast session (the source node, all destination nodes, and all relay nodes) is referred to as a multicast tree. In multicast routing protocols [12], the path between a source and receiver, which consists of multiple wireless hops, suffers very much due to link breaks, and reduces the communication costs for applications that send the same data to multiple recipients.

The primary objectives of MANET routing protocols are to maximize network throughput, maximize energy efficiency, maximize network lifetime, and minimize delay. The network throughput is usually measured by packet delivery ratio while the most significant contribution to energy consumption is measured by routing overhead which is the number or size of routing control packets. There are many multicast routing protocols designed for mobile ad hoc networks and they can be categorized into two broad categories named as Tree-based approach (e.g. MAODV, AMRIS) and Mesh-based approach (e.g. ODMRP) [3,4].

In tree-based multicast protocols, there is only one path between a source-receiver pair. Tree-based approaches create trees originating at the source and terminating at multicast group members with an objective of minimizing a cost function. The main drawback of these protocols is that they are not robust enough to operate in highly mobile environments.

Mesh-based schemes establish a mesh of paths that connect the sources and destinations. They are more resilient to link failures as well as to mobility. The major disadvantage is that mesh-based schemes introduce higher redundancy of packets since multiple copies of the same packet are disseminated through the mesh, resulting in reduced packet delivery and increase in control overhead under highly mobile conditions.

The rest of this paper is organized as follows. Section 2 reviews about the tree based and mesh based multicast routing protocol. Section 3 describes the methodology of proposed protocol. Section 4 explains the simulation scenario setups, and experimental results. Finally, conclusion is given in Section 5.

2. Related work

There are many multicast routing protocols designed for mobile ad hoc networks. Multicast routing protocols in ad hoc networks are faced with the challenge of delivering data to destinations through multihop routes in the presence of node movements and topology changes. Maintaining the multicast tree in a mobile network is essential, to deliver the data to multicast group members.

Wu and Tay [5] proposed an AMRIS protocol which is used to construct a shared delivery tree to support multiple senders and receivers within a multicast session. AMRIS shows a low control overhead compared with other multicast schemes. The link breaks are locally repaired. AMRIS has the smallest number of packet transmissions. There is only one path between member nodes. If a single tree link breaks because of node movements, packet collision, or congestion, destinations cannot receive packets. AMRIS is most sensitive to traffic load.

Lee et al. [6] proposed ODMRP applications for ad hoc networks. ODMRP is a mesh-based, rather than a conventional tree-based multicast scheme and uses a forwarding group concept. It applies on-demand procedures to dynamically build routes and maintain multicast group membership. In ODMRP, no explicit control packets need to be sent to join or leave the group. One of the major strengths of ODMRP is its unicast routing capability. ODMRP produced less control overhead and efficiently utilized those control packets to deliver more data packets to multicast members. ODMRP gets stuck on unidirectional paths and cannot deliver all the packets.

Tavli and Heinzelman [7] described TRACE, which is a medium access control (MAC) protocol. Two features of TRACE make it an energy efficient protocol: scheduling and receiver- based listening cluster creation via information summarization slots. Network lifetime is maximized in TRACE using dynamic controller switching and automatic backup dynamic time-division multiple-access (TDMA) protocol designed for real-time data broadcasting. TRACE protocol is used for data broadcasting only in a single-hop network.

Gerla et al. [8] described ODMRP-ASYM, which is an extension to ODMRP for asymmetric link support. ODMRP-ASYM is designed to achieve complete route discovery by utilizing unidirectional links. This scheme does not introduce any extra overhead if there is no blocking, i.e., no unidirectional link. ODMRP-ASYM can easily overcome unidirectional links and delivers nearly 100% of the packets when the network is connected. ODMRP-ASYM simply avoids unidirectional links but this scheme would fail when biconnectivity exists i.e. cannot be implemented via bidirectional paths.

Junhai et al. [9] described various multicast routing protocols for MANET. Protocols can be grouped either application independent-based multicast routing or application dependent-based multicast routing based on their routing selection principle. This paper also describes the basic functionality of each of the multicast routing protocols. It describes Topology-Based Multicast Routing Protocols, Initialization-Based Multicast Routing Protocols and Maintenance-Mechanism-Based Multicast Routing Protocols.

Tavli et al. [10] described (MH-TRACE), which is a medium access control (MAC) protocol for energy-efficient real-time packet broadcasting in a multihop radio network. In MH-TRACE the overhead in cluster creation and maintenance, is lower when compared with other clustering approaches. MH-TRACE is designed to operate properly in a network with uniform node density. A network with nodes concentrated in a very small area is the worst case for MH-TRACE, because there will be only a few cluster heads and only a small portion of the available bandwidth can be used.

Natarajan Meghanathan[11] proposed a novel network density and mobility aware energy-efficient broadcast route discovery strategy (called DMEF) to determine stable routes in mobile ad hoc networks (MANETs). Each node operates with a maximum transmission range and periodically broadcasts beacons to the neighborhood covered (called the complete neighborhood) within this range. DMEF permits each node to dynamically adjust the transmission range to broadcast the Route-Request (RREQ) messages of the route discovery process.

The objective of this paper is to reduce the energy dissipation in mobile ad hoc network using multicast routing. Maintaining the multicast tree in a mobile network is essential, to deliver the data to multicast group members. The aim of proposed protocol is to establish and maintain an active multicast tree surrounded by a passive mesh within a mobile ad hoc network. The proposed protocol is used to eliminate the redundant data receptions.

3. Description of Proposed Method

3.1. M-EEMC Architecture

The M-EEMC active multicast backbone is a highly pruned tree. Due to node mobility, the initial tree will be broken in time, so M-EEMC is equipped with several mechanisms to maintain the multicast tree.

← Control sub-frame →← Data sub-frame →

Contention slot Header	Information slot	Data slots

Up ID	Down ID	MGroup ID	HDTS	Node Mobility	Node Density	Time Stamp

Fig.1 M-EEMC Frame Structure

Fig.2 Information packet format

The active tree is surrounded by passive mesh and any collapse in the active tree is rapidly repaired or replaced by the passive nodes. Thus, M-EEMC multicasting can be interpreted as an integration of tree- and mesh-based approaches. Time is organized into cyclic constant duration superframes consisting of several frames. Each frame consists of a control subframe for transmission of control packets, and a contention-free data subframe for data transmission as shown in Fig.1. The Information packet includes information about the data packet, for example, in an Information slot, the ID of the corresponding upcoming data packet is announced so that the nodes that have already received the data packet do not waste energy receiving a previously received data packet. Channel access is automatically renewed by the continuous use of a reserved data slot. Fig.2 shows Information packet format, where UpID represents the Upstream node ID, DownID represents the Downstream node ID, MGroup ID represents the Multicast Group ID, HDTS represents the Hop Distance to The Source. Node Mobility represents the node's speed. Node Density represents the number of neighbors of a node. This information is announced through Information slot.Fig.3 shows the architecture design of proposed protocol.

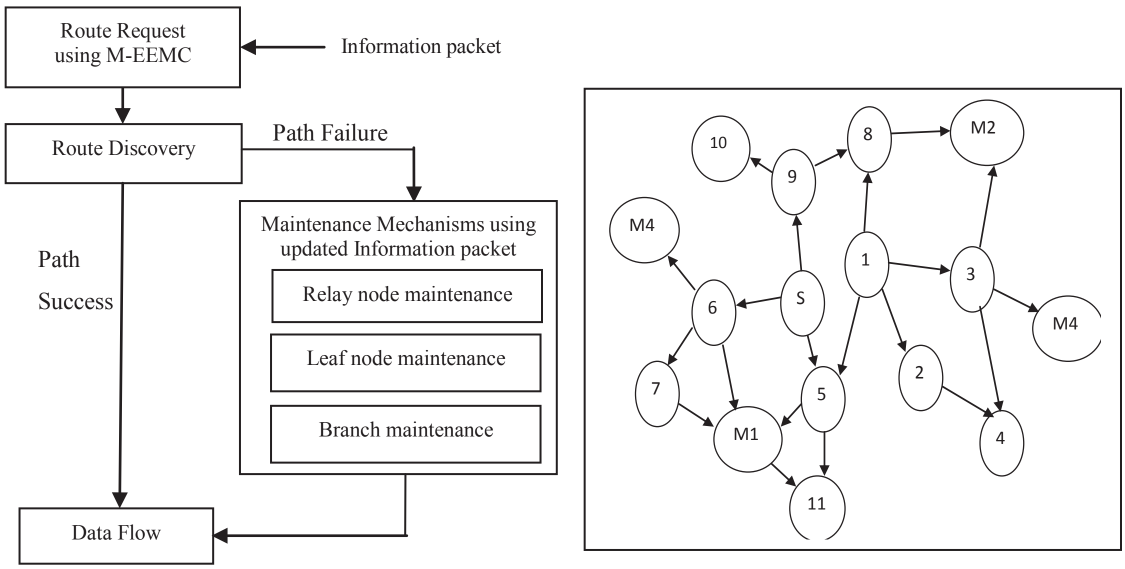

Fig.3 Architecture design of proposed protocol

Fig.4 Route Discovery

3.2. Analysis of building blocks in M-EEMC

3.2.1. Route-discovery

Route-discovery process is initiated by the source node. The source node specifies the entire path in a packet-header itself to the destination node. The route discovery process allows the nodes to discover a path to the destination by using route request packet. Fig.4 illustrates a scenario in which a source node (S) initiates a session by broadcasting packets to its one-hop neighbors. Nodes that receive a data packet contend for channel access, and the ones that obtain channel access retransmit the data they received based upon the number of neighbors surrounding the node and the mobility of the node. The neighborhood size for rebroadcast is reduced and the destination is reached through one or more paths with reduced energy. Such paths are also more stable compared to those incurred using flooding.

Each retransmitting node acknowledges its upstream node by announcing the ID of its upstream node in its Information packet, which precedes its data packet transmission. The source node announces its own ID as its upstream node ID. Initially, all retransmitting nodes announce the null ID as their downstream node ID. However, when an upstream node is acknowledged by a downstream node, the node updates its downstream node ID by the ID of downstream node. The leaf nodes continue to announce the null ID as their downstream node ID. Since each retransmitting node indicates its hop distance to the source (HDTS), node density and node mobility in it's Information packet, it is possible to choose the node with the least HDTS and low mobility as the upstream node. Multicast group member nodes indicate their status by announcing their multicast group ID in the Information packet.

3.2.1.1. Dynamic Selection of M-EEMC Parameter Values

Every node (say node u) in the network is configured with a maximum transmission range (MaxRange). If the distance between two nodes is less than or equal to the maximum transmission range, the two nodes are said to be within the "complete neighborhood" of each other. Each node broadcasts periodically a beacon message in its complete neighborhood. Using M-EEMC algorithm, each node learns about the number of nodes in its complete neighborhood [11].

3.2.1.2. M-EEMC Mathematical Model

M-EEMC effectively uses the knowledge of neighborhood node density and mobility so that they complement each other in discovering stable routes in a more energy-efficient fashion. The transmission range used by a node *u*, Range_u, to rebroadcast a route request message is given by the following model:

$$Range_u^{RREQ} = Range_u^{Max} - \left[\left({|Neighbors_u|}/{\alpha}\right) * v_u^{\beta}\right] \quad (1)$$

In order to make sure, Range_u is always greater than or equal to zero, the value of parameter α should be chosen very carefully. For a given value of parameter β, the necessary condition is

$$\alpha \geq \left[\left({|Neighbors_u|}/{MaxRange}\right) * v_u^{\beta}\right] \quad (2)$$

In practice, the value of parameter α has to be sufficiently larger than the value obtained from (2), so that the route request message reaches neighbors who can forward the message further to the rest of the network. Otherwise, certain source-destination nodes may not be reachable from one another even though there may exist one or more paths between them in the underlying network.

3.2.1.3. M-EEMC ALGORITHM

M-EEMC allows each node to dynamically choose at run-time the appropriate values for the critical operating parameters α and β depending on the perceived number of nodes in the complete neighborhood of the node and the node's own velocity.

Let Neighbors $_u$ and v_u represent the set of neighbors in the complete neighborhood and velocity of a node u at time t. Note that the set $Neighbors_u$ is determined by node u based on the latest periodic beacon exchange in the complete neighborhood formed by the maximum transmission range, MaxRange . Let *MxN_LE*, *MxN_ME, MxN_HE* represent the maximum number of neighbors a node should have in order to conclude that the complete neighborhood energy of the node is low, moderate and high respectively. Let *MxN_LD*, *MxN_MD, MxN_HD* represent the maximum number of neighbors a node should have in order to conclude that the complete neighborhood density of the node is low, moderate and high respectively. Let *LD_α*, *MD_α* and *HD_α* represent the values of α to be chosen by a node for complete neighborhoods of low, moderate and high density respectively. Let *MxV_LM*, *MxV_MM* , *MxV_HM* represent the maximum velocity values for a node in order to conclude that the mobility of the node is low, moderate and high respectively. Let *LM_β*, M*M_β* and *HM_β* represent the values of β to be chosen by a node when its mobility is low, moderate and high respectively. Inputs are Multicast group size, Number of neighbors of a node u, Velocity of a node u.

The Algorithm steps are,

- If the velocity of a node v_u is less than *MxV_LM*, then the mobility of the node (β_u) is said to be low.
- If the velocity of a node v_u is less than *MxV_MM*, then the mobility of the node (β_u) is said to be moderate.
- Otherwise, the mobility of the node (β_u) is said to be high.
- Next step is to find the minimum number of neighbors of node u using the following formula,
  $\min\_\alpha_u = \left[\left({|Neighbors_u|}/{MaxRange}\right) * v_u^{\beta_u}\right]$
- If a node has less than *MxN_LD* number of neighbors, then the node is said to exist in a complete neighborhood of low density.
- If a node has less than *MxN_MD* number of neighbors, then the node is said to exist in a complete neighborhood of moderate density.
- Otherwise the node is said to exist in a complete neighborhood of high density.
- Finally, each node dynamically choose the appropriate values for the critical operating parameters α and β depending on the perceived number of nodes in the complete neighborhood of the node and the node's own velocity.
- Next step is to select the transmission range used by a node u, $Range_u^{RREQ}$, to rebroadcast a route request message is given by the following model:
  $Range_u^{RREQ} = Range_u^{Max} - \left[\left({|Neighbors_u|}/{\alpha}\right) * v_u^{\beta}\right]$
- Find the Residual Energy (RE) for each node n within $Range_u^{RREQ}$ of node u and compare it with thresholds to categorize it as active node of tree or passive node of tree.
- If RE_n is less than MxN_LE then discard that nodes.
- If RE_n is greater than MxN_LE and less than MxN_ME then accept the node as active to form the tree
- If RE_n is greater than MxN_ME then accept the node as passive which form a mesh.

3.2.2. Pruning

The redundancy introduced by Route discovery is pruned by the pruning mechanism using receiver based and transmitter-based feedbacks. After the route discovery process, all the nodes receive the data packets and they determine their upstream and downstream nodes. Multicast relays are also determined. Pruning uses the multicast relays to create an efficient multicast tree. A multicast relay node that does not receive any upstream or downstream ACK for some time ceases to be a multicast relay.

Route discovery and Pruning mechanisms are not always capable of maintaining the multicast tree in a mobile network. Thus, there is a need for additional maintenance mechanism techniques to repair broken branches. Multicast group member node, Relay node and Branch mechanisms are utilized to maintain the multicast tree.

3.2.3. Tree Maintenance Mechanisms

In existing protocols, maintaining the multicast tree in a mobile network is based only on hop distance. But, the proposed protocol is not only depends on hop count, it also depends on node density and node velocity. If any link break is detected, the downstream node uses M-EEMC algorithm to fix the broken link. If any path failure occurs due to node's mobility then every node updates its upstream node ID and downstream node ID in its Information packets. Pseudo code for maintaining the multicast tree in a mobile network as follows,

```
If upstream nodeID changes then
begin
        Find the min-hop node and check velocity and density of that node.
        Use the M-EEMC algorithm to choose the node to get attached.
        Finally, Attach to the new node based on the information from Information packet.
End
```

If any path failure occurs due to node's mobility then three mechanisms applied to maintain the multicast tree. They are,

1. Leaf node (Multicast Group member node) Maintenance Mechanism.
2. Relay node Maintenance Mechanism.
3. Branch Maintenance Mechanism.

3.2.3.1. Leaf node (Multicast Group member node) Maintenance Mechanism

The initial multicast tree formed by pruning is broken in time due to node mobility. Tree branches broken primarily due to leaf node (multicast group member node) mobility are repaired by this mechanism. Some of the multicast group members are not multicast relays.

Whenever a multicast group member node moves away from one node's transmit range and enters another node's transmit range. Then the multicast group member node either begins to acknowledge new node as its upstream node or it just receives the data packets from the new node based on the information from Information packet (i.e. based on node density and node velocity). In this case, multicast group member node forms a redundant passive outer mesh for the tree branch. Passive nodes in the neighborhood of the tree breakage created an active mesh, which is quickly pruned down to a single path after the tree branch is repaired.

3.2.3.2. Relay node Maintenance Mechanism

The multicast tree formed by pruning is broken in time due to node mobility. Tree branches broken primarily due to relay node mobility are repaired by this mechanism. After a node marks itself as a multicast relay, it continuously monitors its upstream node to detect a possible link break between itself and its upstream multicast relay node. If any link break is detected, the downstream node uses relay node maintenance mechanism to fix the broken link.

Both relay node maintenance and leaf node maintenance mechanisms are limited scope maintenance algorithms (i.e., they can fix mostly one-hop tree breaks). However, in a dynamic network, limited scope algorithms are not always capable of completely eliminating multicast tree breaks, or in some cases, the total collapse of the multicast tree.

3.2.3.3. Branch Maintenance Mechanism

It is possible that due to the dynamics of the network (e.g., mobility, unequal interference), a complete branch of a multicast tree can become inactive, and the leaf multicast group member node cannot receive data packets from the source node. In other words, the entire path for the multicast group is broken. Thus, the branch mechanism is needed. If the entire path for the multicast group is broken then the multicast group member finds the new path with least hop distance to the source. Passive nodes temporarily create the paths (a mesh) between the multicast group member node and the source. The short lived mesh created by the passive nodes between the source and the final destination is highly effective in combating against rapid topology changes. Hence, create branch mechanism is an infrequently utilized mechanism when compared to the other mechanisms, yet without it; M-EEMC is not a complete multicast protocol.

3.2.4. Energy Efficiency

M-EEMC is designed for maximum energy efficiency in data multicasting, and there are several mechanisms that enable this:

- M-EEMC effectively uses the knowledge of neighborhood node density and mobility so that they complement each other in discovering stable routes in a more energy-efficient fashion
- Nodes are only required to be awake and receive packets for a small fraction of time (the Information slot subframe). This time is used for monitoring schedules, for data discrimination of the data flow, and for network control.
- In the remaining time, which is much longer than the Information slot subframe, nodes are mostly in the sleep mode whenever they are not directly involved in data transmission or reception, saving the energy that would be wasted in idle mode or in carrier sensing.
- Nodes can selectively choose what data to receive based on information from the Information packets, enabling the nodes to avoid receiving redundant data.

4. Results And Discussion

4.1. Performance Evaluation

The performance evaluation is carried out as a simulation study using NS2. Table.1 summarizes the simulation parameters. In the simulation, we have modeled a network with 50 mobile nodes placed randomly and all the nodes are mobile in nature. Both the protocols, ODMRP and M-EEMC are simulated independently at different time and the performance metrics are evaluated independently.

4.1.1. Performance Analysis Metrics

- Packet Delivery Ratio-It is the ratio of the number of packets delivered to the multicast nodes to the number of packets generated by the source node, normalized by the number of multicast nodes.
- Energy Throughput-This is the average of the ratio of the number of data packets reaching the destination to the sum of the energy spent across all the nodes in the network.

Table 1. Simulation parameters

Parameter	Value
Network topology	1000*1000
Number of nodes	50
Transmit range	250 m
Initial Energy	100W
Low Density	10
Moderate Density	20
High Density	40
Low Velocity	5m/s
Moderate Velocity	10m/s
High Velocity	20m/s
Low Energy	0.3954mj
Moderate Energy	0.7908mj
High Energy	1.186mj

The performance of M-EEMC is compared with ODMRP. The performance metrics of M-EEMC is evaluated under three stages. In Fig.5 (a), Energy dissipation of M-EEMC is compared with ODMRP. In Fig.5 (b), PDR of M-EEMC is compared with ODMRP.

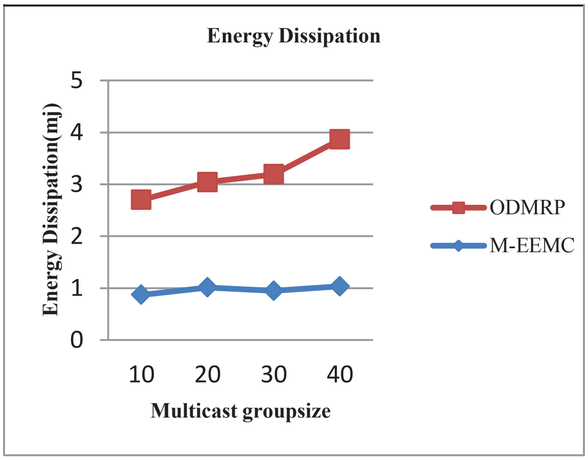

Fig.5 (a) Comparison Graph for Energy dissipation

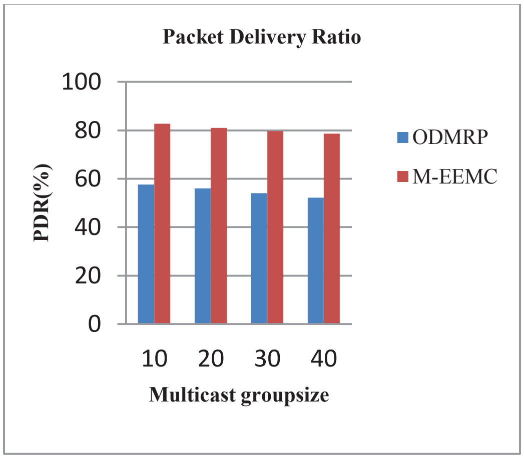

Fig. 5 (b) Comparison Graph for PDR

4.2. Discussion

From the comparison of two protocols, M-EEMC produces high packet delivery ratio than ODMRP and also M-EEMC achieves less energy dissipation than ODMRP**.** If any path failure occurs in ODMRP, it doesn't get the new path for the entire multicast group. But M-EEMC can easily detect the broken links by using maintenance mechanisms and find the new path for the entire multicast group.

5. Conclusion

In this paper, a new multicast routing protocol called Mobility based Energy Efficient Multicast Protocol (M-EEMC) was introduced, which is a combination of tree and mesh based structures. M-EEMC is a tree-based approach, yet it can preserve the tree branches in high mobility. It can detect broken tree branches rapidly, with the support from the passively participating neighboring nodes around the active branches, and then repair the broken links. M-EEMC achieves less energy dissipation by eliminating the redundant data receptions. This scheme produces a high packet delivery ratio, because all the nodes are continuously relaying all the packets. The performance of M-EEMC is evaluated and compared it with ODMRP. M-EEMC produces less energy dissipation and provides better packet delivery ratio than ODMRP.

References

[1] Perkins.C, Ad Hoc Networking: Addison - Wesley:2001;1-28

[2] X. Chen, J. Wu, "Multicasting Techniques in Mobile Ad-hoc Networks", Computer Science Department, SouthWest Texas State University, San Marcos, The Handbook of Ad-hoc Wireless Networks (2003) pp. 25–40.

[3] Chansu Yu, Ben Lee, Hee Yong Youn, "Energy Efficient Routing Protocols for Mobile Ad Hoc Networks"

[4] Broch, J., Maltz, D. A., Johnson, D. B., Hu, Y. C. and Jetcheva, J." A Performance Comparison of Multi-hop Wireless Ad hoc Network Routing Protocols", Proceedings of the 4th Annual ACM/IEEE Conference on Mobile Computing and Networking, pp. 85 – 97,1998.

[5] Wu C.W. and Tay Y.C., "AMRIS: A Multicast Protocol for Ad Hoc Wireless Networks," Proc. IEEE Military Comm. Conf., vol. 1,pp. 25-29, 1999.

[6] Lee S.J., Su W., and Gerla M. "On-Demand Multicast Routing Protocol in Multihop Wireless Mobile Networks," Mobile Networks and Applications, vol. 7, pp. 441-453, 2002.

[7] Tavli B. and Heinzelman W., "TRACE: Time Reservation Using Adaptive Control for Energy Efficiency," IEEE J. Selected Areas Comm., vol. 21, no. 10, pp. 1506-1515, Dec. 2003.

[8] Gerla M., Lee Y.-Z., Park J.-S., and Yi Y., "On Demand Multicast Routing with Unidirectional Links," Proc. IEEE Wireless Comm. And Networking Conf., pp. 2162-2167, 2005.

[9] Junhai L., Danxia Y., Liu X., and Mingyu F., "A Survey of Multicast Routing Protocols for Mobile Ad-Hoc Networks," IEEE Comm. Surveys and Tutorials, vol. 11, no. 1, pp. 78-91, First Quarter 2009.

[10] Tavli B. and Heinzelman W., "MH-TRACE: Multi Hop Time Reservation Using Adaptive Control for Energy Efficiency," IEEE J. Selected Areas Comm., vol. 22, no. 5, pp. 942-953, June 2004.

[11] Natarajan Meghanathan, "Performance Comparison Study of Multicast Routing Protocols for Mobile Ad hoc Networks under Default Flooding and Density and Mobility Aware Energy-Efficient (DMEF) Broadcast Strategies", Informatia Journal,2011

[12] Jose Anand, D. Srinath, "Performance Analysis of Shared Tree based Multicast Routing Protocols for Ad-hoc Wireless Networks,"International Journal of Engineering and Technology, Vol. 2, no. 1, March 2009.

[13] The Network Simulator NS-2: http://www.isi.edu/ ns-nam /ns.